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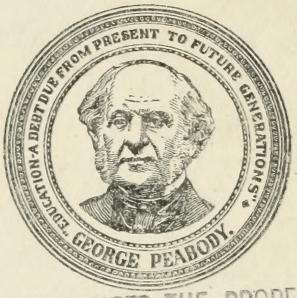

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BIOLOGY OF THE LOTUS BORER (PYRAUSTA PENITALIS Grote).

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INTRODUCTORY.

In American literature two distinct species have been confused under the name *Pyrausta penitalis* Grote. One of them, the smartweed borer, has recently been described as new under the name *P. ainsliei* by Carl Heinrich (*16*[1]), of the Bureau of Entomology. The other, the lotus borer, described originally by Grote (*1*) and later redescribed by Smith (*3*) as *Botis nelumbialis*, has been casually studied by several observers, but up to the present time no complete account of its biology has been available. The two species are closely related and very similar, in many morphological and biological characters, to the recently introduced European corn borer, *P. nubilalis* Hübner. It seemed possible that a close study of the life history and habits of the two native species might bring to light some facts which would help in determining the potentialities of the new pest. In accordance with this plan the first paper dealing with *P. ainsliei* from the biological side has already been published (*18*). The present paper deals with the similar aspects of *P. penitalis*. Both the results

[1] Reference is made by number (italic) to "Literature cited," p. 13.

of the writers' observations and previously published data are included herein. The morphology and diagnostic characters of this and the other species mentioned, which have already been admirably worked out by Heinrich (*16*) and also by Flint and Malloch (*17*) and Mosher (*13*, *15*), are largely omitted from this discussion.

SYSTEMATIC HISTORY.

Pyrausta penitalis was first described by Grote (*1*) under the generic name Botis from material taken on *Nelumbo lutea* at Lawrence, Kans. In 1890 it was redescribed by Smith (*3*) as *Botis nelumbialis* from "Egyptian" (more properly "Indian") lotus, *N. nucifera*, at Bordentown, N. J. Thinking that he was dealing with this species, Coquillett (*2*) published some notes on a form which has since been shown (*12*, *14*) to be distinct, probably *P. futilalis*. Riley and Howard (*4*, *p. 349*), Townsend (*5*, *p. 467*), Coquillett (*7*, *pp. 15*, *17*, *19*, *27*), and Viereck (*11*, *p. 453*) record parasites which will be more fully noted later. Hart (*6*, *p. 180*), gives some scattered biological information and descriptions of the various stages as observed on *N. lutea* along the Illinois River. Coquillett (*7*) first used the name in its present form, and Dyar (*9*, *p. 391*) lists the species as occurring in the south Atlantic States, with *B. nelumbialis* Smith as a synonym. Chittenden (*12*) summarized all the facts available up to the time of his paper and from them formulated a tentative life cycle which, because of the fact that he was considering two species, one of them at the time undescribed, will have to be considerably modified. Welch (*14*) has made the latest contribution to our knowledge of the species, and his observations, made at Sandusky Bay, Lake Erie, although good, are incomplete as to life history, because they covered only a small part of the growing season. His conclusions, however, come nearer the facts than any hitherto published.

STUDIES AT KNOXVILLE, TENN.

FIELD COLLECTIONS.

The authors' work on the species dates from July 19, 1919, when, after considerable search, a plantation of the yellow lotus or water chinquapin (*Nelumbo lutea*) (Pl. I) was located at Kimberlin Heights, about 15 miles from our laboratory at Knoxville, Tenn. This plantation consisted of a dense border of the plants surrounding a mud-bottomed pond of about 3 acres on the campus of a small denominational school. It was said that the plants had started several years before from seeds thrown into the pond by one of the students. As nearly as the authors have been able to ascertain, this is now the only occurrence of the plant in eastern Tennessee, although it is known

that before the coming of the white man the Indians cultivated it for its edible seeds and rootstocks in many places along the Cumberland and Tennessee Rivers.

The first examination showed that the plants were heavily infested by the very insect the writers desired to study. Throughout the rest of the season of 1919 frequent careful studies were made of the conditions at Kimberlin Heights, and quantities of material were brought to the laboratory for closer study and for rearing purposes.

At the time of the first visit, July 19, the main blooming season was closing. There were still a few flowers and scattering buds. None of the seed pods had ripened, but the oldest ones were fully grown. A count showed that there were 472 pods in all stages in the plantation. Of these, 80 (17 per cent) showed work of the larvæ and were collected and examined individually. They contained 39 empty pupal shells, 23 pupæ, and 2 larvæ in the prepupal stage. Moths began to emerge at once, or, more properly, continued to emerge from the pupæ until July 28, when the last one appeared.

On July 19, larvæ, evidently the progeny of the earliest moths, were found feeding on the leaves. These larvæ were mostly small, only a few half grown, and none mature. When taken to the laboratory for rearing they began to pupate July 28, and the first moths of this generation emerged August 4. From this time on there was a continual overlapping of generations, larvæ both from the later moths of the first generation and from those of the second being inseparably mixed. From these larvæ and from others collected on July 28, moths continued to emerge until August 27. On August 5 no very small larvæ could be found. The youngest observed probably were in the third instar, but several egg masses were found, so it seemed probable that the last moths of the first generation had not yet disappeared. On this same date it was also found that the larvæ of this generation instead of seeking pupation quarters in the seed heads were burrowing in the upper ends of the petioles of the older leaves, preparing there a pupation chamber, and that a few had already pupated. One empty pupa shell was found in this location, which seemingly indicated that the second generation of moths had just begun to emerge. More pupæ and prepupal larvæ subsequently were found in the petioles, and larvæ, in gradually lessening numbers, still feeding on the leaves and in the petioles, were found until September 18. Three were found on this date, but thereafter the most thorough search of the lotus and of all likely hiding places in the vicinity of the pond failed to reveal a trace of their whereabouts.

A further and more careful study in this locality was planned for 1920, but for some obscure reason the lotus was very much less vigorous. Comparatively few leaves and buds appeared and only a few small larvæ were found in colonies on June 29.

REARING RECORDS.

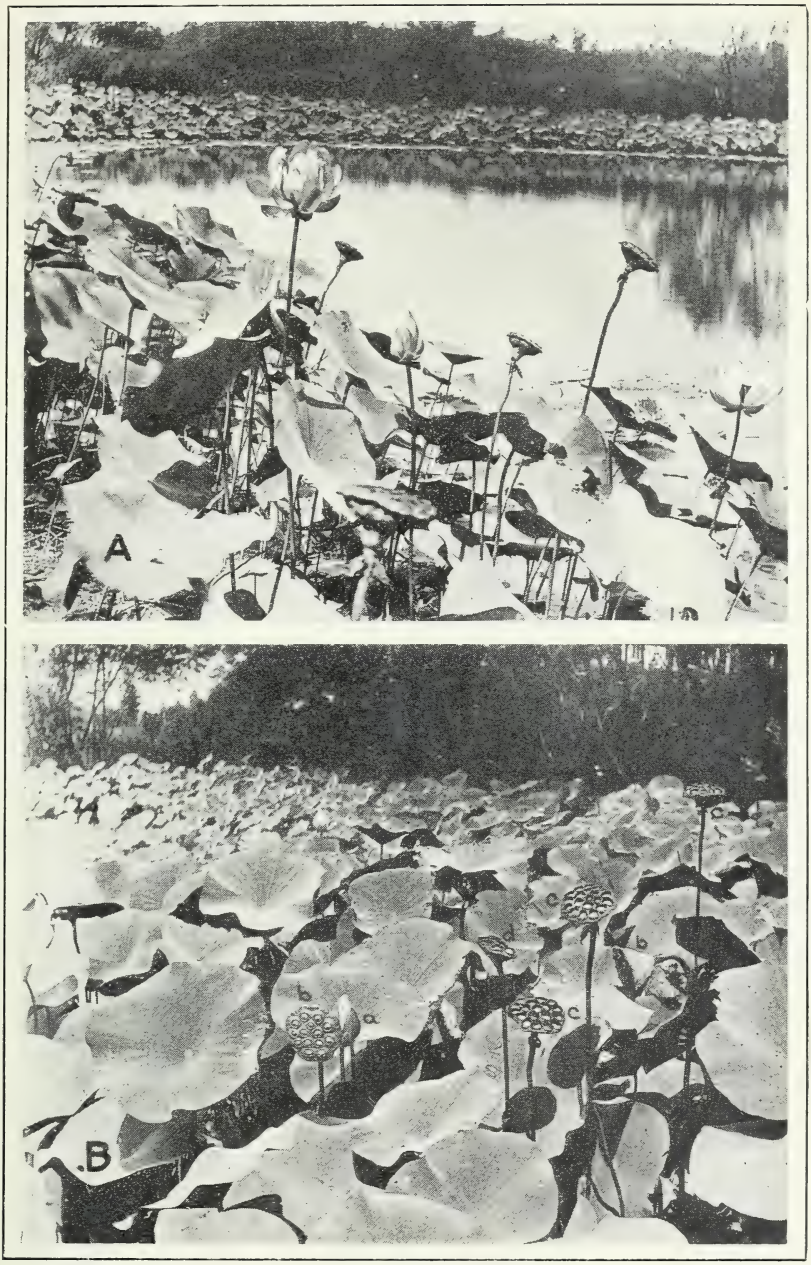
So much for field observations. On each examination of the pond material was collected and brought to the laboratory for rearing. The results obtained throw additional light on the seasonal habits of the moths. As stated above, pupæ taken in the seed heads July 19 continued to develop moths until July 28. Larvæ taken at the same time on the leaves varied greatly in size, some of them being very small. The first of these pupated July 28, the last August 15. Moths emerged from August 4 to August 22. Another collection of larvæ made from the leaves July 28 pupated August 3 to August 18, and moths emerged August 12 to August 27. A mass of eggs found August 6 hatched August 9, and the larvæ were reared. They pupated August 28 to September 2, and the moths emerged September 9 to September 17. Another series of larvæ taken both from petioles and leaf blades on August 5 pupated from August 6 to August 22, and moths emerged August 13 to August 29. Larvæ from a lot of 67 collected August 15 pupated from August 17 to September 12, and moths emerged August 28 to September 22.

LIFE CYCLE.

Assuming for the present, as seems probable, that the species passes the winter in the larval stage, it is evident that the life history must be substantially as follows:

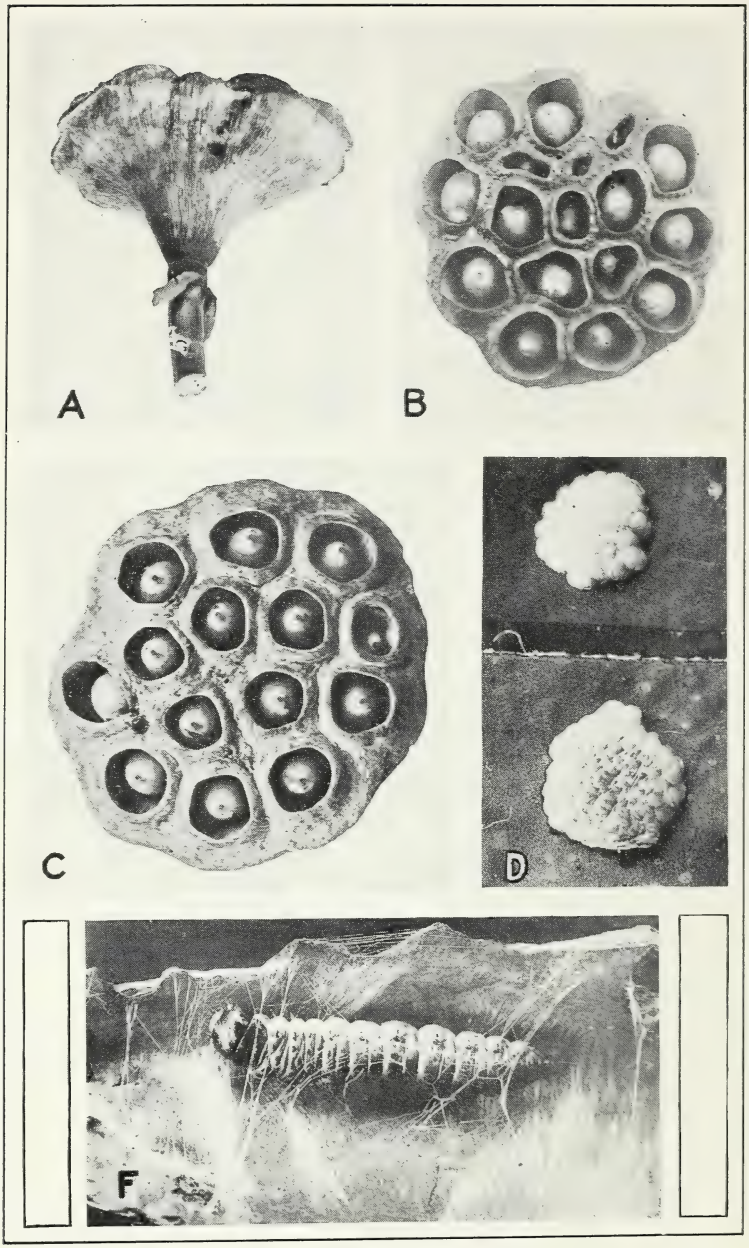
The overwintering larvæ pupate and the moths emerge and oviposit about mid-June. The resulting larvæ feed on the leaves, and when fairly grown, about July 1, seek the flowers and enter the young pods, feeding upon them to some extent and pupating within them. The moths of this first generation emerge from July 7 to July 28. Eggs are at once produced by these moths and constitute the first stage of the second generation. The eggs soon hatch, and the oldest of the larvæ produced are approximately half grown by July 19; but moths of the first generation continue to oviposit until about August 5, so that second-generation larvæ are hatching continuously from July 10 to August 8. A collection of these larvæ made July 28 pupated August 3 to 18 and moths emerged August 12 to 27. These larvæ of the second generation feed on the leaves and pupate in the upper ends of the leaf petioles.

The moths of the second generation give rise to the third-generation eggs and larvæ, which survive the winter and constitute the spring generation. It seems possible that some of the smaller larvæ of the second generation seek hibernation quarters instead of completing their growth the same fall. In this case there would be only two generations annually, but it seems probable that there are three generations as a rule. Their behavior from the time the larvæ seek



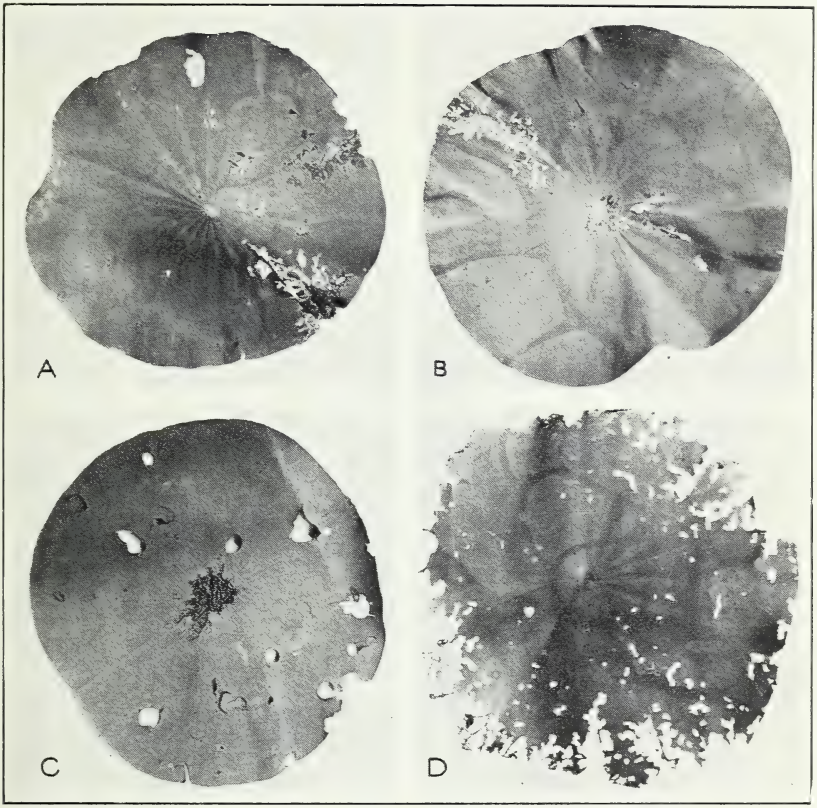
PYRAUSTA PENITALIS.

A, Partial view of pond at Kimberlin Heights, Tenn., showing *Nelumbo lutea* flowers, ripe pods, and margin of old dying leaves floating on water. *B*, Method of pod development in lotus: *a*, Bud; *b*, growing pods in horizontal position; *c*, erect, mature pods; *d*, pod deformed by work of borer.



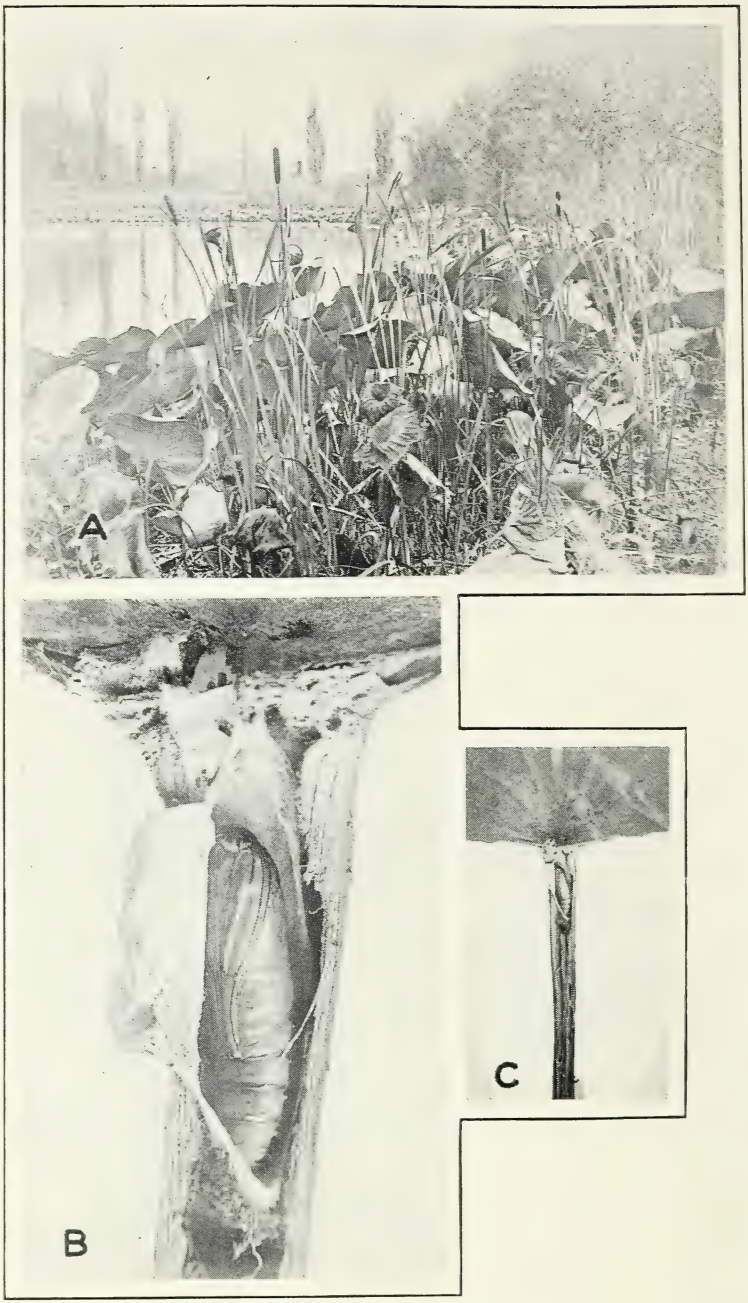
PYRAUSTA PENITALIS.

A, Under side of infested pod, showing entrance hole of borer. *B*, Same pod as in *A*. Face view showing deformed sockets and seeds caused by work of larva beneath. *C*, Face of another pod, showing less common method of entrance. *D*, Egg masses on leaf surface. *F*, Larva beneath web on leaf.



PYRAUSTA PENITALIS.

A, Injured leaf. *B*, Leaf bearing both central and peripheral feeding areas. *C*, An old floating leaf, showing mound of frass covering the opening to the pupal chamber in the petiole beneath. *D*, An old, much eaten leaf after the remaining membrane has dried and dropped out.



PYRAUSTA PENITALIS.

A, Portion of plantation at Kimberlin Heights, Tenn., showing close association of lotus and cat-tail rush. *B*, Upper end of leaf petiole, opened to show pupal cavity and cocoon. *C*, Same as in *B*. Leaf cut in half and petiole split to show position of pupal cavity.

winter quarters in the fall until the young larvæ of the first generation appear on the leaves in June is unknown, and the outline here given for that period is hypothetical.

FEEDING HABITS ON THE LEAVES

After hatching, the larvæ feed gregariously for a time, gnawing off the epidermis of the leaf in irregular patches, first protecting themselves with a shielding network of brownish silk stretched across some slight concavity of the leaf or producing such a concavity by its tension. They soon scatter, each forming a similar retreat of its own (Pl. II, F), either in the center of the leaf above the petiole attachment or around the margin where the edge is easily drawn up a little to form the necessary free space beneath the web (Pl. III, A, B). Less often a larva locates on the blade between the center and the margin. Protected and partially screened by the webs, the larvæ strip the epidermis from the leaf, those at the center in a more or less radiate pattern and those at the margin following the periphery. They extend their retreat as they exhaust the food supply and occasionally prolong the feeding area irregularly inward toward the disk of the leaf. At no stage is the entire substance of the leaf eaten. The areas from which the epidermis is stripped soon turn brown, dry, and fall out, leaving the leaf lacelike along the margin (Pl. III, D) and generally tattered in appearance.

Although at Kimberlin Heights no larvæ were observed in the act, it is evident that they moved about from leaf to leaf and from one portion of a leaf to another. Small feeding webs were often found uninhabited, and tiny larvæ were found in retreats evidently occupied previously by much larger ones. Where several larvæ occurred on one leaf the retreats often overlapped around the margin, giving the effect of a large retreat occupied by several larvæ. No evidence was found of the larvæ swimming from one leaf to another as was observed by Welch in Lake Erie. The leaves were in almost every case contiguous to each other, especially when swayed by the breeze, and no need for such a means of locomotion was apparent. Then, too, the old floating leaves, loose from their petioles, drifted back and forth across the pond before the wind and, working in among the standing leaves, formed pontoon bridges between the petioles. (Pl. I, A.)

One exceptional instance was observed in which a leaf standing somewhat by itself but not especially isolated was found with a series of six holes in the petiole between the blade and water, each of which opened into a short cavity containing a fully mature larva evidently preparing to pupate. Not another larva was found in such a location, and this case can only be explained on the ground

that the larvæ marooned on this leaf, unable to seek their usual pupation quarters, were forced to enter the petiole.

From laboratory experiments it was found that when placed in water the larvæ, especially those nearly mature, were sustained on the surface film and were able to make considerable progress by lateral contortions. When once fully submerged, however, they were unable to regain the surface. Larvæ of *Pyrausta ainsliei* under the same conditions behaved similarly but did not advance as rapidly when swimming.

FEEDING HABITS ON THE PODS.

The larvæ of the first generation apparently utilize the green, growing pod for food as well as for pupation. After the floral parts fall away, the pod normally droops (Pl. I, B, *b*) until its flat, seed-bearing face is vertical, becoming erect again when nearly mature (Pl. I, B, *c*). Until maturity the seeds remain tightly embedded in their sockets, and only as the pods ripen, turn brown, and dry do they become loose, ultimately to be shaken out and sink in the water and mud around the plants.

In entering the young pod the larva usually selects a point just below the rim and on the underside of the pod as it hangs horizontally (Pl. II, A); less often it cuts in between the seeds on the flat face of the pod (Pl. II, C). As the larva feeds within, soft brown frass is pushed out of the entrance hole in considerable quantity, eventually drying and falling away or being washed off by rain. The interior of the fruit or pod is filled with parenchymatous tissue through which run the vascular bundles nourishing the developing seeds. After entering, the larva eats out more or less of a cavity in this soft tissue and often cuts into or through two or three or more of the seeds. Whenever a seed is injured even slightly or the vascular bundle beneath it is cut, it turns brown and soon shrivels to a mere remnant. These empty or partially empty sockets (Pl. II, B) are very conspicuous and almost invariably indicate the presence or work of the larvæ. Such injured pods are also frequently much distorted (Pl. I, B, *d*) and very unlike the ornamental, perfect specimens. Although in a few cases the cocoon was found near the face of the pod and, in fact, lying partially in and through some of the injured seeds, the larva usually makes its way well toward the base of the pod before cocooning.

In the pods collected at Kimberlin Heights July 19 the normal number of seeds per pod varied from 10 to 25, with an average of 17. The work of the larvæ resulted in the destruction of 5.9 seeds on the average in each infested pod, or 34.7 per cent of the total number in the infested pods and 5.88 per cent of those in the entire plantation. The pods developing from the scattering flowers which

continue to appear after the main blooming season are generally smaller, contain relatively few seeds, and often have empty sockets due to incomplete fertilization.

So far as is known, this lotus has at present no economic value other than its very obvious qualifications as an ornamental plant. The work of the larvæ of this insect on the leaves (Pl. III) is conspicuous and unsightly, and the attacks on the pods result in many misshapen and distorted specimens as well as in the outright destruction of an appreciable proportion of the seeds.

PUPATION OF THE FIRST GENERATION.

Pupæ of the first generation are formed in dense, tough, papery cocoons in the growing pods. The cocoon is not conspicuous even when the pod is opened, as it is stained and studded with brownish excrement like the walls of the burrow. In the great majority of cases it lies well toward the base of the pod with its long axis parallel with the vascular bundles running to the seed sockets. Less often it is found lying partially within or through one or more of the partly consumed seeds. The cocoon and pupa are so much larger than the seeds that it seems impossible for the pest ever to be accidentally distributed in them. Larvæ have been found lying entirely within a single immature seed but never a pupa. In the cocoon the pupa lies with its head toward the entrance, and after emergence occurs the pupal shell remains entirely within the cocoon. The moth escapes from the pod by the same opening through which the larva entered it.

PUPATION OF THE SECOND GENERATION.

In the second generation the pupal habits are quite different, and considerable search was required to locate the cocoon and pupa. Even though a few pods continued to develop from stray flowers, they were found attacked by larvæ in only one or two cases, and the increasing number of larvæ reaching maturity made it certain that they were seeking other quarters. Two possibilities were open—the over-curled margins of the leaves and the petioles. The leaf margins yielded only a very occasional pupa, not enough to solve the problem, and the petioles, standing as they did from 15 to 30 inches above the water and offering apparently ideal conditions for a pupal burrow, remained unscarred. To be sure, an occasional shallow pit was found in the upper end, opening to the upper surface of the leaf blade, but never one large enough to contain a larva.

The lotus at least in this plantation holds the leaves high above the water on their stiff and milky-juiced supporting petioles until, either from maturity or because of serious injury to the leaf surface, they have about reached their limit of usefulness. The petioles then

weaken and allow the leaf disks to drop to the surface of the water (Pl. I, A), where they soon yellow, decay, and sink. When these mature floating leaves were examined it was found that in the center of the disk, directly above the petiole attachment, a large number of the leaves had a round opening leading to a cavity in the upper end of the petiole (Pl. IV, B, C). This cavity was shallow, seldom extending more than 2 centimeters into the petiole, and usually just long enough to accommodate the larva and its cocoon. The entrance was often surrounded and covered by a mound of soft brown frass pellets (Pl. III, C), and frequently the surface tissue of the leaf in an irregular area about it was scarred and eaten as if the larva after constructing the cavity possessed still an appetite which it satisfied with the nearest food at hand.

In the case of the prepupal larvæ or pupæ the cavity in the petiole is lined with a substantial white silk fabric, densest at the upper end (Pl. IV, B). The entrance is closed with a very accurately cut whitish lenticular disk of plant tissue which fits closely and is sealed in with silk. This disk lies usually a little below the level of the leaf surface and is concealed by the frass until the latter is washed away or otherwise removed. This position of the pupal cavity, in the floating leaves only, brings it below the water level.

Welch (*14, p. 219–221*) has well described the construction of this pupal chamber and the feeding in connection therewith, and the behavior of the insects was found here to correspond closely with his account. It is noteworthy, however, that in Lake Erie, where his observations were made, the lotus leaves are always floating and not held above the water, and their centers are higher than the periphery, while at Kimberlin Heights the leaves are held 15 to 30 inches above the water and are cupped with the margins higher than the centers, so that they often catch rain or dew to the amount of several cubic centimeters and hold it until it evaporates or is spilled by the swaying of the leaves in the wind. The insect evidently prefers to construct its cocoon in an aquatic situation and so seeks the old floating leaves at the approach of maturity. Never were young or partly grown larvæ found in the petioles, only those nearly mature and probably in the last instar. Neither are the young and erect leaves attacked in this way; only the old, floating ones.

HABITS OF THE MOTHS.

The only moths seen in the open were the few found in and near the lotus plantation. Several of them were captured and found to be predominantly males. Their flight was rapid and erratic, and they were wary and not easily approached. They came to rest usually on the lower side of a lotus leaf and often flew among the petioles and beneath the canopy formed by the leaves 2 or 3 feet

above the water. No data are available as to the length of life of the moths in the open. A series of reared moths retained alive in tin boxes supplied with a wad of wet cotton furnished the data on this point contained in Table I.

TABLE I.—*Length of life of reared moths in confinement (in terms of days).*

Sex.	Maximum.	Minimum.	Average.	Number of moths averaged.
Male	14	2	6.77	27
Female	13	3	7.72	43

THE EGG.

The act of oviposition has not been observed, but very probably occurs toward dusk or at night. Nothing was known about the egg until Welch (*14, p. 214*) observed and rather incompletely described it. The authors have found numbers of the masses (Pl. II, D) at various times, and as their observations differ in some points from those of Welch a description in somewhat greater detail is included.

The egg: Thin, flat, elliptical in outline, 0.98 millimeter long, 0.56 millimeter wide, chorion finely reticulated with narrow elevated lines and in addition finely longitudinally wrinkled, dingy yellow or amber color when laid, soon developing a narrow darker border and a paler opaque central area. They are laid in thick circular masses of 40 to 80 eggs, 2.5 to 3 millimeters in diameter and 0.47 millimeter thick, each egg overlapping its predecessor shingle-fashion, about three-fourths covering it and lying at an angle of approximately 45° with the leaf surface, the mass being dingy yellow in general color. The larva leaves the egg through a transverse slit in the exposed end. After hatching the mass is dirty gray in color, somewhat shining, and much flatter than before. It is then very loosely attached to the leaf and easily removed by a slight touch.

The writers failed to note any matrix such as Welch describes. They did, however, note the frequent absence of the empty egg mass on leaves bearing very small larvæ, but attributed the fact to the ease with which the empty egg mass is washed or blown from the leaf. A number of the egg masses were found, both unhatched and empty, and one in which the eggs were parasitized. They seem to be placed at any point on the upper surface of the leaf and when present on an unblemished leaf are easily seen.

It has, of course, been impossible to determine how many eggs are normally laid by a female in the open. The possibilities are indicated, however, by results obtained from reared moths confined in tin boxes and supplied with moisture. Of 43 females so confined only 15 oviposited. The number of eggs produced by an individual varied from 9 to 504, with an average for the 15 of 143 eggs. These moths

were all isolated before emergence and remained virgins throughout their lives, so these figures are doubtless below the normal.

FOOD PLANTS.

Unless some food plant other than lotus is inhabited by this insect, it is difficult to explain its presence at Kimberlin Heights. From present knowledge of its habits it is inconceivable that it came with the seeds, and no other lotus is known to exist within possible range of flight of this moth. To determine whether the species is indigenous or introduced, the writers have made plantings of lotus seed in several isolated ponds many miles distant from this infestation.

Because of the confusion in the literature between this species and *Pyrausta ainsliei*, several food plants have been attributed to it which manifestly are erroneous. The only natural food plants which have so far been reliably ascertained are the yellow lotus, *Nelumbo lutea*, and the Indian lotus, *N. nucifera*, the latter an introduced species.

Smith (*10, p. 525*), mentions having found these larvæ in stems of cat-tail flag, *Typha latifolia*. At Kimberlin Heights conditions were ideal for such a transfer, because the lotus and cat-tail grew intermingled in several places (Pl. IV, A). In attempts to find where the larvæ went for the winter, practically every cat-tail plant in the vicinity of the pond was thoroughly dissected and examined. With the single exception of one larva found behind a leaf sheaf no trace of attacks on this plant were found.

In confinement in the laboratory partly grown larvæ, taken on lotus, fed readily and completed their growth on leaves of smartweed (*Polygonum pennsylvanicum*), buckwheat (*Fagopyrum fagopyrum*), and dock (*Rumex crispus*). In other series, larvæ were reared from egg to adult on the same plants but the authors have never seen any indication that these plants are used as food by this insect under natural conditions. Numerous aquatic and subaquatic plants and a large number of the common wild plants and weeds were offered to the larvæ, but all were refused except those mentioned. It is noteworthy that the normal food plants of *P. ainsliei* are Polygonaceae but that that species can not develop on lotus. There is a suggestion here of some common ancestry for the two species, with members of the Polygonaceæ as their food plants, and that *P. penitalis*, having taken to lotus comparatively recently, has not entirely lost its taste for the smartweed family.

ENEMIES.

In the course of its life several perils threaten the safety of this insect. It does not seem to us that Welch's point (*14, p. 218*), as to the construction of the silken web being a special adaptation to its

aquatic environment, is well taken, for many leaf and tree-feeding caterpillars, exposed to the same or to greater risks, do not construct protective webs and, on the other hand, many larvæ living in sheltered and well-protected situations do build burrows or webs—within which to work. Be that as it may, there is probably little danger of wind or waves washing these caterpillars off the leaves.

DIPTEROUS PARASITES.

From living enemies, however, they do not escape so easily. According to the literature four species of tachinid flies have been reared from the larvæ. Townsend (*5*) lists *Exorista hirsuta*. O. S. (now *E. vulgaris* Fall.) and *Phorocera comstockii* Will. as having been reared by Forbes in Illinois. Coquillett (*7, p. 17, 19*) adds *Hypostena variabilis* Coq. and *Panzeria penitalis* Coq. to this list. Because of the confusion between *Pyrausta penitalis* and *Pyrausta ainsliei* and the impossibility of finding from the literature the exact source of the material from which the parasites were reared, it is possible that not all of these species attack the true *Pyrausta penitalis*. *Panzeria penitalis*, for one, is known to be a parasite of *Pyrausta ainsliei*, and there is no definite record of its ever having been reared from lotus-feeding larvæ. All of these records should be verified in the light of our more exact knowledge of their hosts.

HYMENOPTEROUS PARASITES.

Among the hymenopterous parasites, *Bracon xanthostigma* Cress. is listed by Riley and Howard (*4, p. 439*) as a parasite of this borer on lotus at St. Louis, Mo. Viereck (*11, p. 223*) lists *Meteorus communis* Cress. with the simple statement that it parasitized *P. penitalis*. Hart (*6, p. 180*) mentions one secondary and two primary parasites, but without determinations. We recognize at least one of his parasites, the braconid, making white cocoons singly on the leaf surface. (Pl. III A.) This one, determined as *Apanteles harti* Vier. by A. B. Gahan, was found to be the most common at Kimberlin Heights. Its small white cocoons (1.5 by 4 millimeters) are firmly fastened to the leaf disk either under the webbing or exposed outside. In July they were only occasionally seen, but by early September were much more common and were killing from 10 to 25 per cent of the larvæ. This species evidently attacks the smaller larvæ and completes its life as a parasite when its host is scarcely more than half grown. None of them developed from larvæ larger than this. From 7 to 10 days elapsed between the spinning of the cocoon by the parasite and the emergence of the adult.

Another parasite, very likely the other mentioned by Hart (*6, p. 181*), which the writers found only a little less common than the foregoing, is an undescribed, yellowish brown species of Microbracon (de-

termined by Gahan). The parasitic grubs to the number of about a dozen emerge from their host larva shortly before time for the pupation of the latter. They then spin a mass of brown silk cocoons so tightly compacted that it is difficult even to determine their number. This mass is found in the burrow or partially constructed cocoon of the host. In more than one instance adults of this parasite were found well within the larval burrow of the host, evidently hunting opportunities for oviposition, but it is not known just how or at what age the host larvæ are attacked.

In three instances *Chalcis ovata* Say (det. Rohwer) was reared from the pupæ by the authors.

The authors found but one case of egg parasitism. One egg mass was taken which appeared darker than normal. When retained in a vial, part of the eggs hatched normally, but the rest, which had meanwhile turned jet black, gave forth adults of *Trichogramma minutum* Riley (det. Gahan), one from each egg.

SCAVENGERS.

Very often small dipterous maggots were found in the empty burrows or feeding on decaying larvæ or pupæ. A number were reared, and two species of flies were obtained, *Aphiochaeta chaetoneura* Malloch (det. Greene), and *Elachiptera nigriceps* Loew (det. Aldrich). These were undoubtedly scavengers, and nothing was observed to indicate that they were in any way injurious to sound larvæ or pupæ. They seem to thrive equally well on putrid vegetable matter. Coquillett (*8*) mentions rearing the latter of the two species from the same situation many years earlier.

OTHER ENEMIES.

A somewhat peculiar catastrophe was found to happen very often to the larvæ which had prepared their pupation chambers in the upper end of the petioles of the floating leaves. Some animal, evidently, took a bite out of the side of the petiole close under the leaf, thereby cutting into the cavity and its occupant. In some such cases the cut-out portion of the petiole was left hanging, in others it was gone, and often the predator had bitten the petiole entirely off at this point. No portion of the larvæ or pupæ was ever found in the cavity, and the work was very evidently done intentionally in search for the insect. Often uninfested petioles were cut, evidently by mistake. The possible authors of the work were (1) ducks, a small flock of which frequented the pond; (2) frogs, of which there were many, some of them very large; (3) fishes; and (4) turtles. The character of the work eliminates the ducks and frogs because their jaws are not sufficiently strong to make such clean cuts as these were. No direct evidence of the presence of fish was found, and in such

a pond it would not be usual to find fish capable of doing such work. There remain the turtles, whose heads were frequently seen above the water. The authors were unable to capture any to examine their stomach contents, but by elimination they appear to be the most probable authors of the mischief. Doctor Welch writes that he observed nothing of the kind in Lake Erie. The effect of the work of this depredator was a substantial reduction in the number of larvæ reaching maturity.

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